Yuhuan Wu tone and the role of sonorant onsets

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Abstract

Co-occurrence restrictions on tones and consonants in Yuhuan Wu Chinese syllables provide a powerful illustration of the phonetic basis of phonological contrasts, with sonorant contexts allowing more tone contrasts than other contexts. Interestingly, the language also reveals that the phonetic implementation of tones depends on the phonological contrast it is involved in. Such phonetic enhancement may be the opposite of what could be expected on the basis of speech ergonomics. Moreover, the language has a tone deletion rule that exempt tones in the context with the largest number of contrasts, showing a phonological version of enhancement.

Index Terms: tone, enhancement, Wu

1. Introduction

The relation between phonetics and phonology is bidirectional. On the one hand, phonetic considerations determine the structure of phonological systems, because the interacting ergonomics of speech production and speech perception will be reflected in them (e.g. [1],[2],[3]). We will refer to this connection as the ergonomic relation between phonetics and phonology. On the other hand, the articulatory implementation of phonological forms will reflect the phonological contrasts in them [4]. Speech production is biased towards enhancing specific contrasts and the articulation of the same feature will therefore vary across languages as a function of the contrasts it is involved in ('phonetic knowledge' [5]). In turn, phonetic measures to protect contrasts may be incorporated in the language's phonological systems, either as 'transphonologizations', whereby an enhancement feature takes over the contrastive role of a phonological feature, or distributionally, whereby exceptions arise in otherwise general rules [6]. These situations will be referred to as enhancement, where the phonetic behavior has not been incorporated in the phonological structure, and phonologized enhancement [7], when it has, whether as a transphonologized contrast or as a distributional restriction.

2. Segments, syllables and tones

We present the case of the lexical tones of Yuhuan Wu Chinese as one that particularly clearly illustrates these relations. The variety is spoken in Yuhuan County in the southeast of Zhejiang Province and has some 300,000 speakers. Like other Wu Chinese dialects, notably Shanghainese, Yuhuan Wu has a number of co-occurrence restrictions on consonants and tones in the same syllable.

2.1. Segmental structure

The language's consonant system is given in Table I.

Table I. Contrastive consonants of Yuhuan Wu Chinese

	labial	coronal	velar	glottal
plosive	b p p^h	d t t^h	g k k^h	ʔ
affricate		dz ts ts^h		
nasal	m	n	ŋ	
fricative	f v	s z	x	ɦ
lateral		l		

Onsets and codas are optional. All consonants can occur as onsets, except /ʔ/. Only /ʔ/and /ŋ/ can occur in the coda. The vowels that occur in open syllables are given in Table II. In addition, syllabic /z̩/ occurs after onset /s, z/, while syllabic /ŋ/ occurs more generally.

Table II. Contrastive vowels of Yuhuan Wu Chinese in open syllables

	Front unround	Front unround	Back unround	Back round
high	i	y		u
mid	ɛ	ø		o
diphthong	ei			əu
low			ɑ ɑ̃	ɔ ɔ̃

Additionally, the vowel /ə/ appears in closed syllables. Rimes ending in /ʔ/ have /i, ɛ, ø ,o/ or /ə/, while rimes ending in /ŋ/ have /i, o/ or /ə/. Discounting the onset consonant, some rimes may begin with [j, w], which we interpret as prevocalic /i, u/. Prevocalic /i/ appears before /u, ɛ, ø, ɔ, ɑ, ɑ̃/ and /oŋ/, while prevocalic /u/ appears before /ɛ, ei, ɔ̃, ɑ, ɑ̃, əŋ/ and /oʔ/. The syllable structure is thus (C)(G)V(C), where G stands for the prevocalic glide. The labiovelar prevocalic glide appears only after velars and the glottal /ɦ/ as well as syllable-initially; the palatal prevocalic glide appears syllable-initially and after all onset consonants except /f, v, x, ŋ/.

2.2. Tones and consonants

The first distinction to be drawn is that between sonorant rimes, those containing just a vowel or a vowel-plus-/ŋ/, with or without prevocalic glide, and glottal rimes, those ending in /ʔ/, again with or without prevocalic glide. The number of tone contrasts in sonorant rimes is five, H, L, HL, ML, LH. However, the presence of a glottal coda restricts that number to two, H and L, notated as Hq and Lq to indicate their occurrence in glottal rimes. This is shown in Table III. The explanation for this restriction is the short duration of the voiced portion of glottal rimes [7]. The reason for the reduced number of contrasts is the short duration of the sonorant portions of glottal rimes. Over five randomly chosen words with H-tone in each category, sonorant portions of glottal

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rimes average 122 ms, against 438 ms for sonorant rimes. This is evidently a connection between phonetics and phonology of the first kind.

Table III. Tone contrasts in sonorant and glottal rimes

li	H	*plum*
li	HL	*surname*
li	L	*plough*
li	LH	*pear*
li	ML	*separate*
loʔ	Hq	*sway*
loʔ	Lq	*fall down*

Sonorant consonants have a constriction in the vocal tract that allows the air pressure levels on either side to be relatively equal [8]. Despite the higher air pressure behind the constriction, the relatively open constriction prevents a build-up of air pressure, and the interference by these consonants with the process of vocal fold vibration as occurring during vowels is therefore small or absent. Voiced obstruents, by contrast, have a constriction behind which the air pressure builds up, and any voicing during the constriction will be made difficult, because of the impedance the constriction offers to the air flow and the resulting reduction in the pressure difference below and above the glottis. As a result, the rate of vocal fold vibration during and after voiced obstruents is reduced. During voiceless obstruents, the vocal folds are abducted to prevent voicing. When voicing sets in after them, the tenser vocal folds will tend to vibrate faster than after the voiced sonorants; for references see [9, p. 8]. These considerations explain two features of the Yuhuan tone system. First, after obstruent onsets the number of tone contrasts is smaller than after sonorant onsets. Second, the tones that appear after voiced obstruents form a lower selection than those that appear after voiceless obstruents. This is shown in Table IV, which should be compared with Table III. Again, we are dealing with a connection between phonetics and phonology of the first kind.

Table IV. Tone contrasts after obstruent onsets

p^hi	H	*fart*
p^hi	HL	*drape over shoulder*
p^hi	LH	*semi-finished product*
pɔ	H	*leopard*
pɔ	HL	*precious things*
pɔ	LH	*bag*
bɔ	ML	*hug*
bɔ	L	*carpenter's plane*
bɔ	LH	*robe*

This restricted distribution not only applies to plosives and affricates, with their three-way laryngeal contrast, but also to fricatives, which have a two-way laryngeal contrast. As predicted, in glottal rimes, voiceless onsets can only be followed by H, while voiced obstruents can only be followed by L.

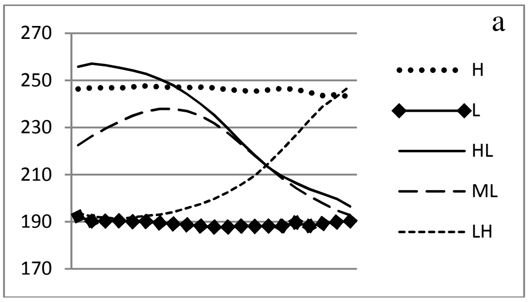
An apparent deviation from the distribution shown in Tables II and IV concerns syllables that begin with phonetic [w] and [j], after which six tones appear. Closer inspection of the beginnings of these syllables, however, indicates that such syllables with H and HL are onsetless, while those with L and ML begin with /ɦ/. The two rises, which differ in pitch range, are to be analyzed as LH occurring after onsetless syllables and syllables beginning with /ɦ/. In the onsetless syllables, a weakly released glottal closure often occurs, which never occurs in the syllables beginning with /ɦ/. Moreover, weak breathy voice may attend syllables beginning with /ɦ/. Strikingly, however, neither of these features appears to be obligatory. Table V presents the contrasts in sonorant rimes after onsetless syllables and syllables beginning with /ɦ/ which contain a prevocalic glide. Two tones appear in glottal rimes, H after onsetless syllables and L after /ɦ/-initial ones.

Table VI. Tone contrasts in onsetless and /ɦ/-initial rimes

uei	H	*fed up*
uei	HL	*bowl*
uei	LH	*hello*
ɦuei	L	*meeting*
ɦuei	ML	*refuse*
ɦuei	LH	*(proper name)*

The distribution in Table VI shows that the prevocalic glide is not an onset. If it were, it would have to be classed as a sonorant consonant. That is, there would have been five tones after a phonetic [w] or [j], not six. As it is, onsetless syllables pattern with voiceless obstruents, while /ɦ/-initial rimes pattern with voiced obstruents. Phonetically, this makes sense, since a glottal closure involves vocal fold tensing. Phonologically, there is a problem with the characterization of voiceless obstruents and zero as a natural class. Analyzing empty onsets as containing /ʔ/ would not work, since the glottal stop is not [-voice], nor are voiceless obstruents [+constricted glottis].

We recorded isolated syllables with all five tones and onset and coda conditions as illustrated in Tables III and IV from three speakers. Average time-normalized f0 tracks for one speaker are given in Fig. 1, pooled over onset conditions, for sonorant rimes (panel a) and glottal rimes (panel b). The pitch range is approximately 60 Hz, small for a female speaker; the values for H and L are fairly constant across tones; ML differs from HL in having a lower starting point.



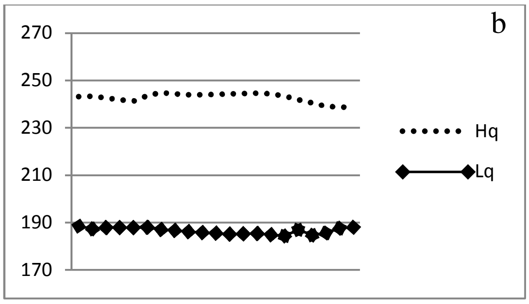


Figure 1: *F0 tracks on normalized times scales for H, L (n=24), HL (n=56), ML, HL (n=36) (panel a) and Hq (n=20) and Lq (n=16) (panel b). Speaker WL.*

3. Phonologized enhancement

Varieties of Wu have prosodic words, aka tone units, whose tonal pattern tends to be determined by the leftmost or rightmost syllable. On the basis of an investigation of disyllabic prosodic words, we find that Yuhuan preserves the tone on the rightmost syllable, and as such provides the mirror image of Shanghainese [10, 11]. That is, tones on non-final syllables are deleted. This is illustrated in Fig. 2, which shows the five (seven) tones before final LH. Thus, the final tone(s) don't spread left; rather, the preceding syllable is pronounced at mid or low pitch, a default pitch for what we take to be toneless syllables. Middish pitch appears in the case of H and LH (approx. 193 Hz), low pitch in the case of underlying L, ML, Hq and Lq (approx. 178 Hz). Differences of that magnitude are found in many cases of phonological identity in the data, and we cannot at this point say if the difference between the two groups of tones is systematic.

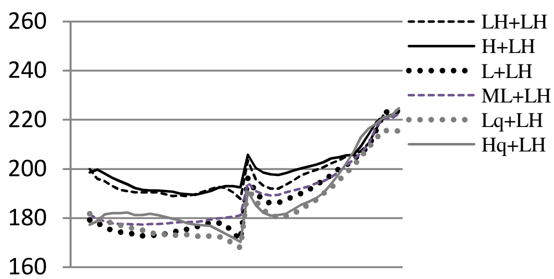


Figure 2. *F0 tracks on normalized times scales for LH, H, L, ML before final LH. Speaker WL.*

There is, however, a striking exception to this tone deletion rule. HL in syllables with a sonorant onset consonant does not delete. This non-final tone deletion rule is given in (1). Fig. 3 presents the fate of HL before LH and L.

(1) Pre-final tones are deleted, except HL in a syllable with a sonorant onset.

There are two questions that this exception raises. One is why HL is preserved after sonorant rather than obstruent onsets. The answer lies in the number of contrasts that are neutralized by the deletion. After obstruents, the reduction is from three forms to one, a loss of two; after sonorants, it is from five forms to two, a loss of three. A loss of four would place a greater strain on the system, which is apparently enough for it to be prevented. The other question is why it is HL rather than one of the other four tones that is preserved. One possible answer is that it provides the clearest phonetic contrast with mid or low pitch, another that it is the most frequent tone in this kind of syllable. In a corpus of 80 random syllables, the highest number is for L (23), followed by ML (20), HL (16), LH (10) and H (9). This suggests that only the first answer is correct. Relative to mid pitch, neither H nor L are very distinct, while because of their smaller pitch range, both ML and LH are closer to mid pitch than is HL. We show HL preservation in syllables with sonorant onsets before LH and L in Fig. 3.

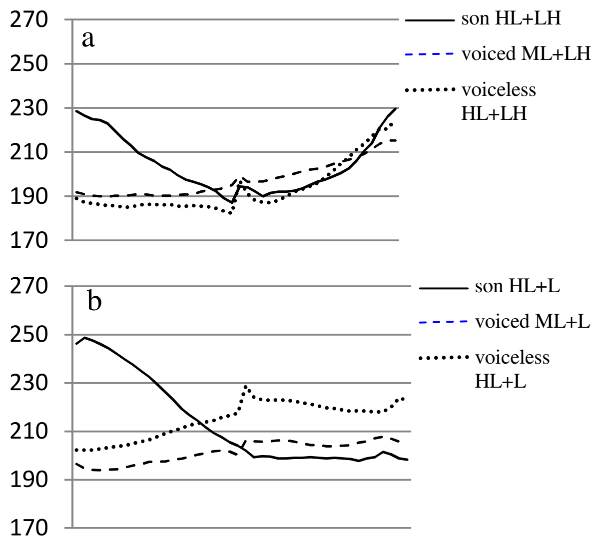


Figure 3: *F0 tracks on normalized times scales for HL before final LH (panel a) and L (panel b) broken down by the phonological specification of the onset (sonorant, voiceless obstruent and voiced obstruent). Speaker WL.*

Summarizing, because onset sonorants have no appreciable physiological effect on the f0 of the rime, Yuhuan Wu has more tone contrasts after sonorant onsets than after obstruent onsets. This distribution presupposes an analysis of initial glides as pre-nuclear glides in the rime, as opposed to onset glides. The observation illustrates the effect of phonetic ergonomics on phonological structure. Second, because there is a larger number of tones after sonorant onsets, an otherwise general tone deletion rules exempts HL from deletion if it occurs in rimes preceded by a sonorant onset. The exception illustrates that phonetic implementation will respect and preserve phonological contrasts, which tendency may in turn lead to distributional restrictions.

4. Phonetic enhancement

Phonetic enhancement can be observed in the way ML is pronounced in syllables with sonorant onsets as compared with voiced obstruents. If things were left to the phonetic implementation without regard for the place of the phonological representation in the system of contrasts, sonorant onsets would have no effect on the f0 of the initial part of the rime, while after voiced obstruents, the f0 of the first part of the rime would be depressed somewhat due to the impedance of offered by the constriction. After voiceless obstruents, the initial f0 after HL would be elevated relative to the situation for HL after sonorant onsets. In reality, the elevation after voiceless obstruents is negligible. Panel (a) of Fig 4 shows that there is no difference in the pronunciation of HL in the two onset conditions. This suggests that the tendency for raised f0 after voiced obstruents is counteracted by a similar raising of the pitch after sonorants. Since it is only after sonorant onsets that the contrast between HL and ML exists, a comparison for ML should reveal the policy behind the lack of a perturbation effect in panel (a). Panel (b) in fact shows that the initial pitch after sonorant onsets in considerably *lower* than after voiced obstruents, against expectation, if expectation is based on speech ergonomics. By contrast, if we take into consideration that speech behavior is guided by contrast enhancement as well as speech ergonomics, the pattern in panel (b) can be understood as a manifestation of 'phonetic knowledge' [5].

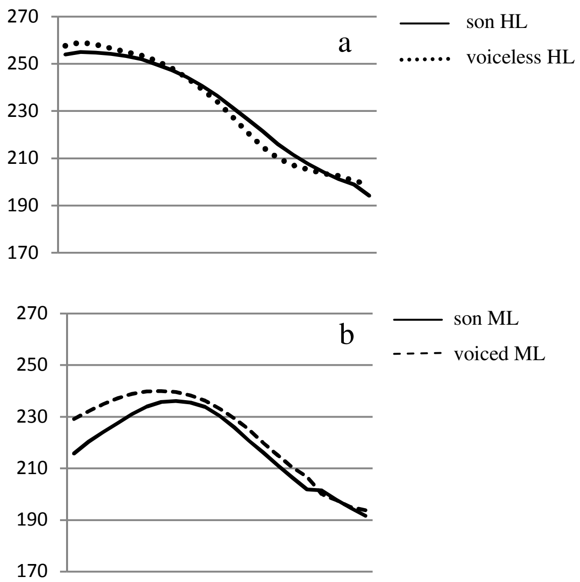


Figure 4: *F0 tracks on normalized times scales for HL with sonorant and voiceless obstruent onset (panel a) and ML with sonorant and voiced obstruent onset (panel b). Speaker WL.*

5. Discussion

Yuhuan Wu appears to be a textbook case for the illustration of the complex relation between phonetics and phonology. On the one hand, phonological systems reflect the opportunities afforded by the speech production and perception systems for creating phonological contrasts, the speech ergonomic connection [1, 2, 3]. In particular, patterns of f0 perturbation by onset consonants explain why there are five tone contrasts after sonorant onsets and three after onsetless or obstruent onsets. Similarly, the large difference in duration between sonorant and glottal rimes explains why glottal rimes have two tone contrasts and sonorant rimes five [7]. On the other hand, contrast enhancement is illustrated by the exceptional retention of HL in pre-final position just in the situation that the onset is sonorant, whereas H, L, ML and LH are deleted in all onset conditions. This suggests that exhaustive deletion of the five-way tone contrast would have jeopardized the maintenance of a comfortable level of lexical distinctions.

Finally, the rationale behind the distributional pattern arising from post-sonorant tone retention is suggested by the phonetic enhancement of the ML tone after sonorant onsets. It consists of a lowering of the initial part of the pitch contour which is more extreme that the physiologically induced lowering due to onsets consisting of voiced obstruents. This shows the enhancement of the contrast between HL and ML in the only context in which it exists, in sonorant rimes after sonorant onsets.

Phonetic enhancement, therefore, may lead to new phonological contrasts ('transphonologization'), but may also lead to restrictions in the distribution of phonological features. Having said that, we cannot be certain about the developmental path that led to the exceptional retention of HL in prefinal sonorant-initial syllables [12]. The deletion may have started gradually, with the retained tones lagging behind as motivated by contrast preservation, which pattern ultimately became phonologized. Alternatively, the deletion may have involved one tone first, which rule then expanded its focus tone by tone, stopping short at HL.

6. Conclusions

The tone grammar of Yuhuan Wu reveals a bidirectional relation between phonetics and phonology. While it has five lexical tones after sonorant onsets in sonorant rimes, lower numbers of tone contrasts appear after obstruent onsets and in glottal rimes. This pattern, variants of which can be found in many languages, in particular Wu dialects of Chinese, is explained by speech ergonomics (f0 perturbation and rime duration). The opposite direction in the relation between phonetics and phonology is shown by a tone deletion rule. Pre-final tone deletion preserves HL if it occurs in a syllable with a sonorant onset. This exception is explained by phonological contrast preservation. Third, the language shows that the contrast between HL and ML, which only appears in sonorant rimes with sonorant onsets, is enhanced, such that the beginning pitch of ML is lower than after voiced obstruents, quite against ergonomic phonetic considerations. After voiced onsets, ML does not contrast with HL, so that less differentiation between the tone sis called for here than om syllables with sonorant onsets.

7. References

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